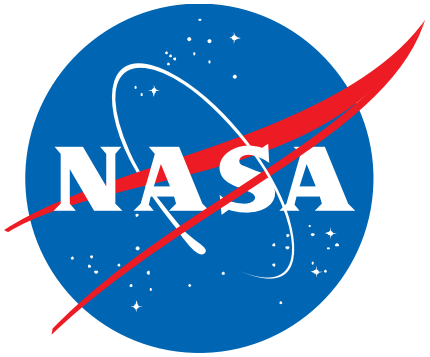

Relative Radiation Risk Reduction for Small Spacecraft and New Designers

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To be presented by Michael Campola at the Electrical, Electronic, and Electromechanical (EEE) Parts for Small Missions, Greenbelt, MD, September 10-11, 2014.

Acronyms

COTS	Commercial Off The Shelf
DDD	Displacement Damage Dose
DOA	Dead On Arrival
EEE	Electrical, Electronic, and Electromechanical
ELDRS	Enhanced Low Dose Rate Sensitivity
NEPP	NASA Electronic Parts and Packaging
RHA	Radiation Hardness Assurance
SEE	Single Event Effect
SWaP	Size Weight and Power
TID	Total Ionizing Dose

Definitions

- Small Spacecraft
  - Mass < 180kg (Small Spacecraft Technology Program)
  - Can be any class mission!
  - Independent of cost, not solely small budgets
- Relative Risk
  - Ratio of the probability of an event occurring in an exposed group to the probability of the event occurring in a comparison, non-exposed group (Wikipedia)
  - Relative risk includes two important features:
    - » Comparison of risk between two "exposures" puts risks in context
    - » “Exposure" is ensured by having proper denominators for each group
  - Not absolute risk
- New Designers – Anyone: EEE Technology or Implementation

Introduction

- Aim and Focus
  - Design trade impacts on radiation
  - Dealing with relative risk
    - » Accounting for all known risks to the system
    - » Categorizing risk based on manifestation at the system level
    - » Ranking priorities based on failure threats
  - Use in class practices
    - » Risk identification and comparison
    - » Test methodologies should be tied to physics of failure

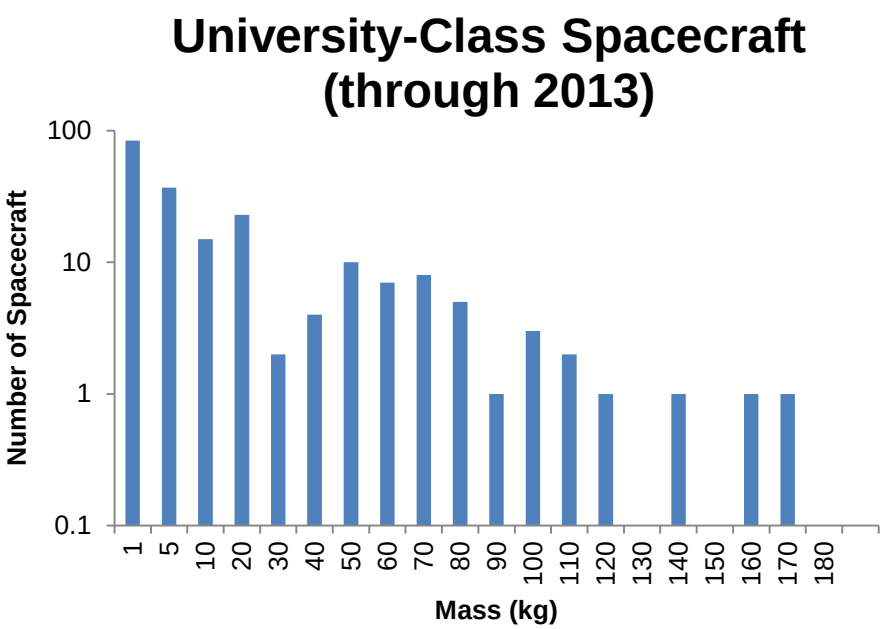
- What I am Not Covering
  - RHA is RHA, not redefining
  - Board-level testing
  - Reducing test requirements
  - Substitute radiation tests
    - » Proton testing for combined TID and SEE
    - » Laser vs. heavy ion testing

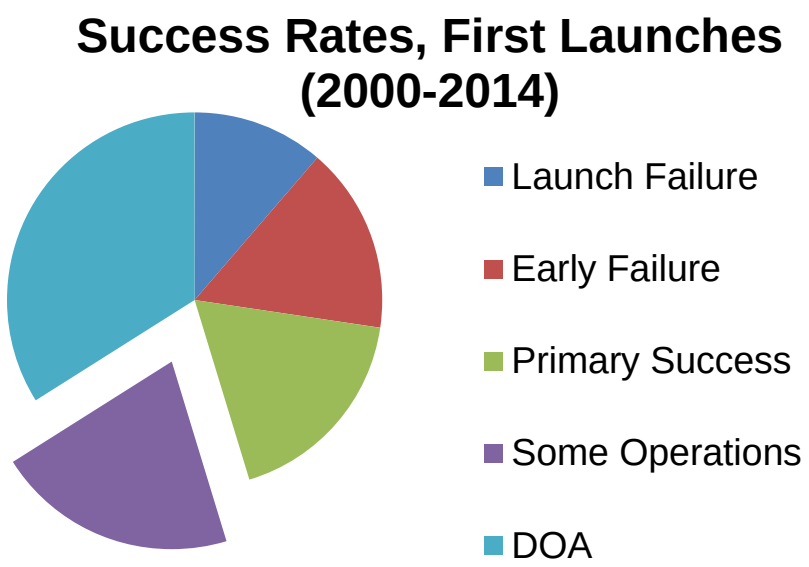
Small Spacecraft “Market Research”

- CubeSat/SmallSat Subsystem Vendors (cubesat.org)

  - Not going to help radiation concerns when trying to drive costs down, do not know your mission objectives
  - Using COTS components in many sub-systems
- Small Spacecraft With New Designers
  - Universities
  - Government Institutions
  - Collaborations

New Designer Scale and Success





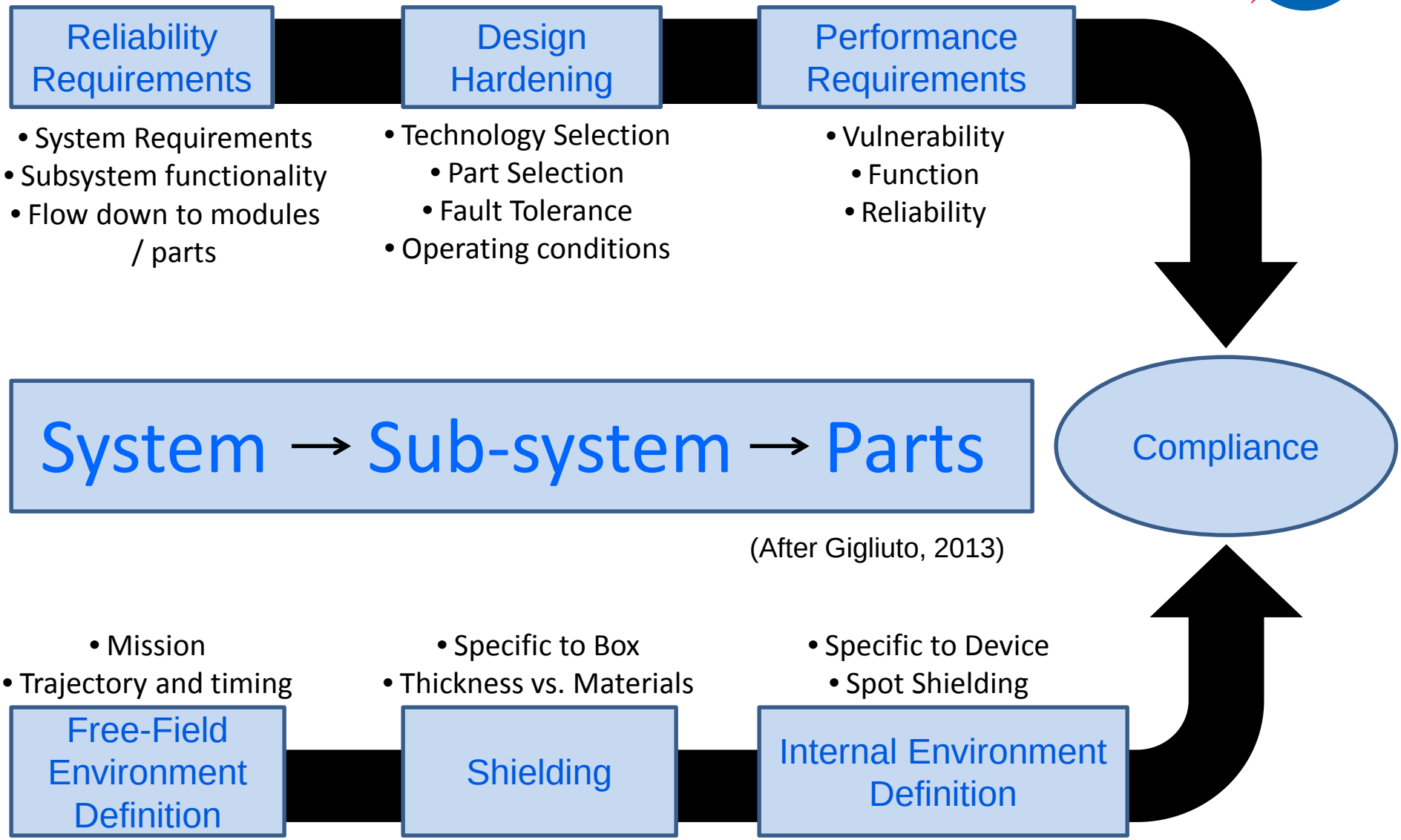
Data from Professor Michael Swartwout at St. Louis University:
https://sites.google.com/a/slu.edu/swartwout/home/cubesat-database

Rational Approach

1. Smart Requirements
2. Evaluate Design/Components
   - Visualize Design Impacts
3. Smart Engineering Decisions with Designers
   - Risk Buy Down
   - Categorize and Rank Risks
4. Iterate Process

(After K. A. LaBel, NEPP 2010)

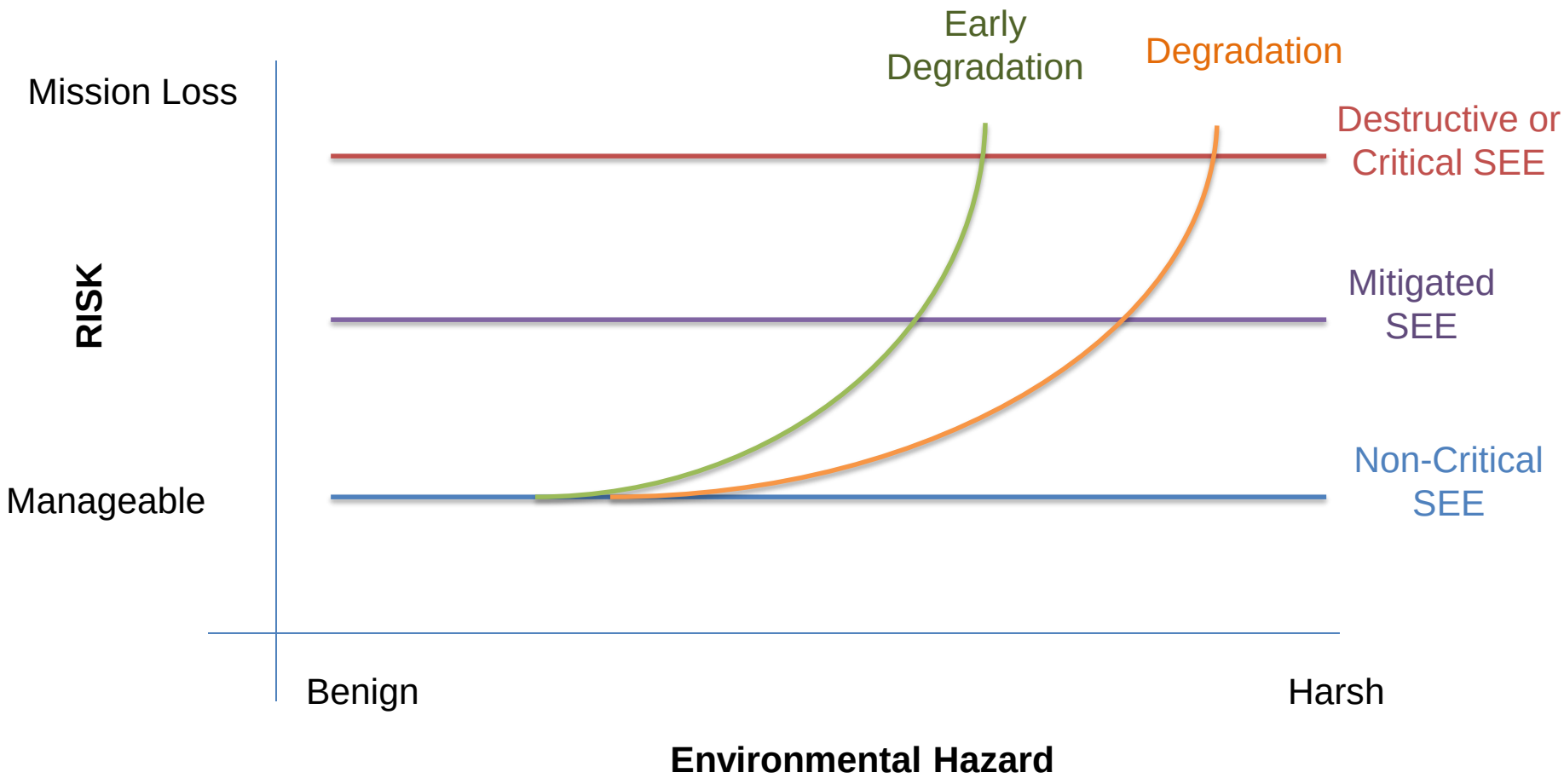
1. Smart Requirements



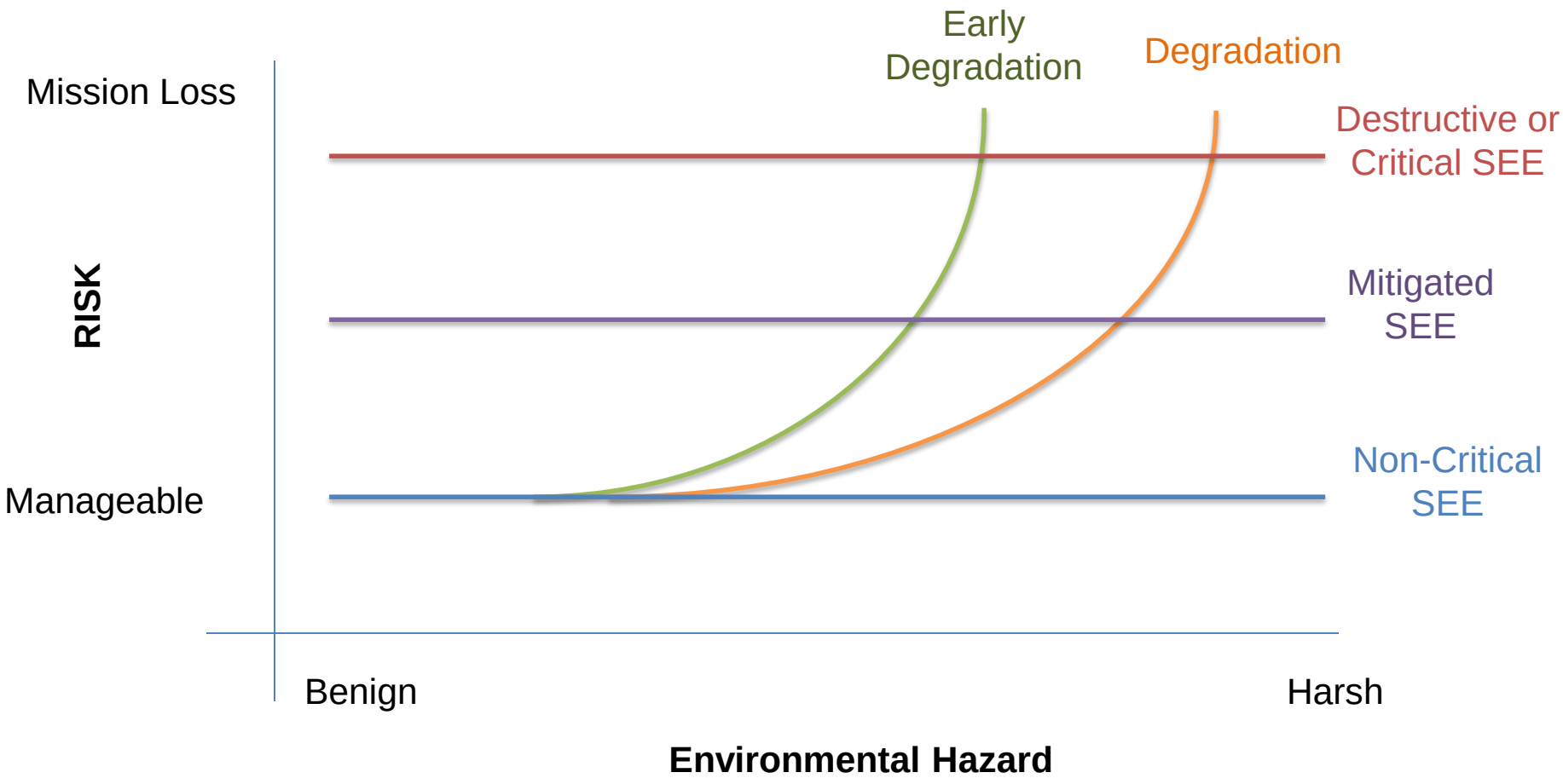
2. Evaluate Design/Components

- Visualizing Design Impacts
  - Mission Duration & Redundancy
    - » Environmental Hazard: Benign or Harsh (considered for SEE or TID/DDD)
    - » System Level Impact: Manageable or Mission Loss?
    - » Early Degradation (ELDRS, TID lot variations, etc.)
- The “we can’t test everything” approach
  - “Please Excuse My Dear Aunt Sally”
    - » $4 + 2\times3 = (4 + 2)\times3 = 6\times3 = 18$
    - » $4 + 2\times3 = 4 + (2\times3) = 4 + 6 = 10$
  - Requirements and risk impacts should determine the order of operations = Relative Radiation Risks

Short Mission → Long Mission



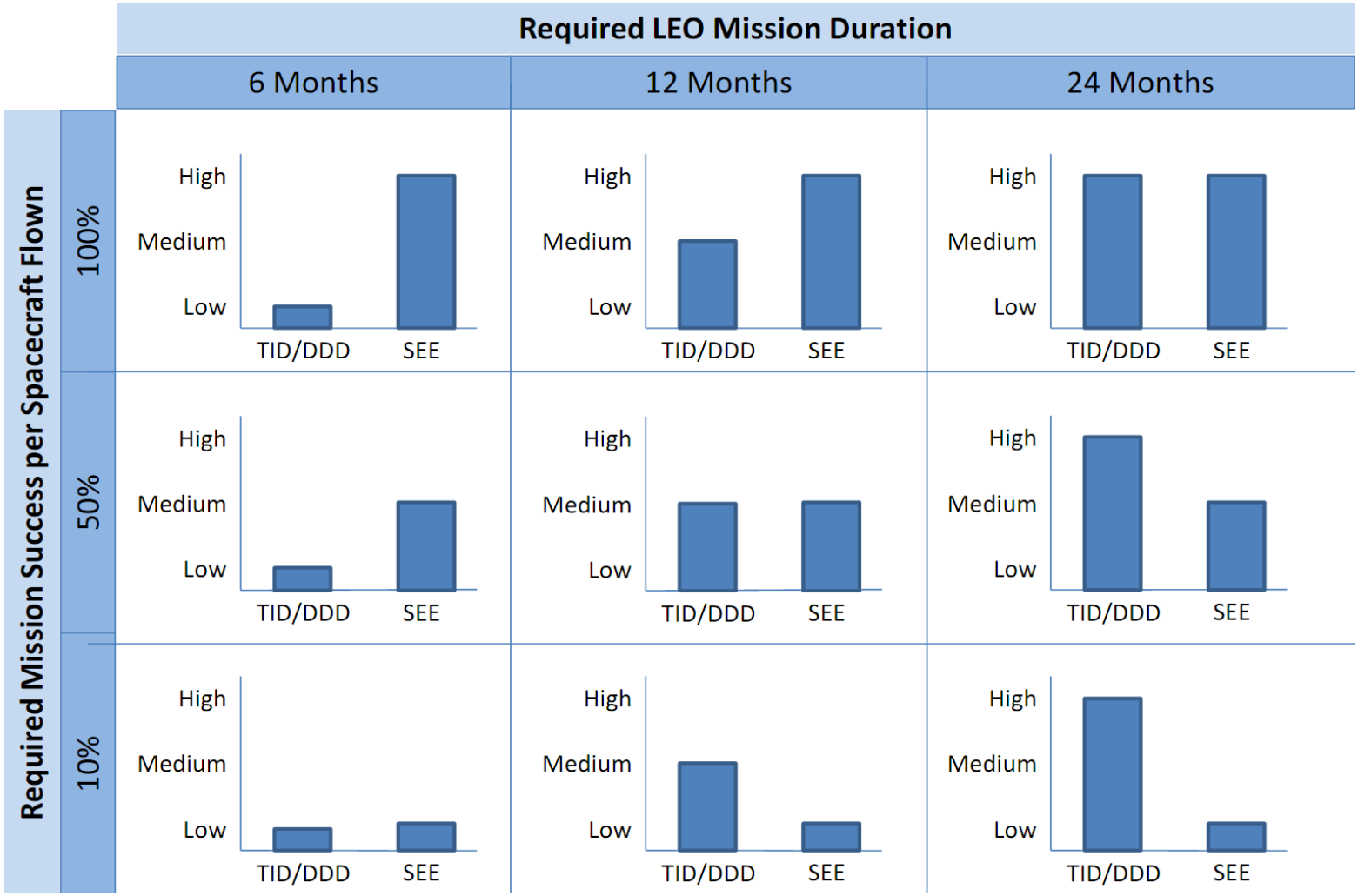
Single String → Redundancy



3. Smart Engineering Decisions

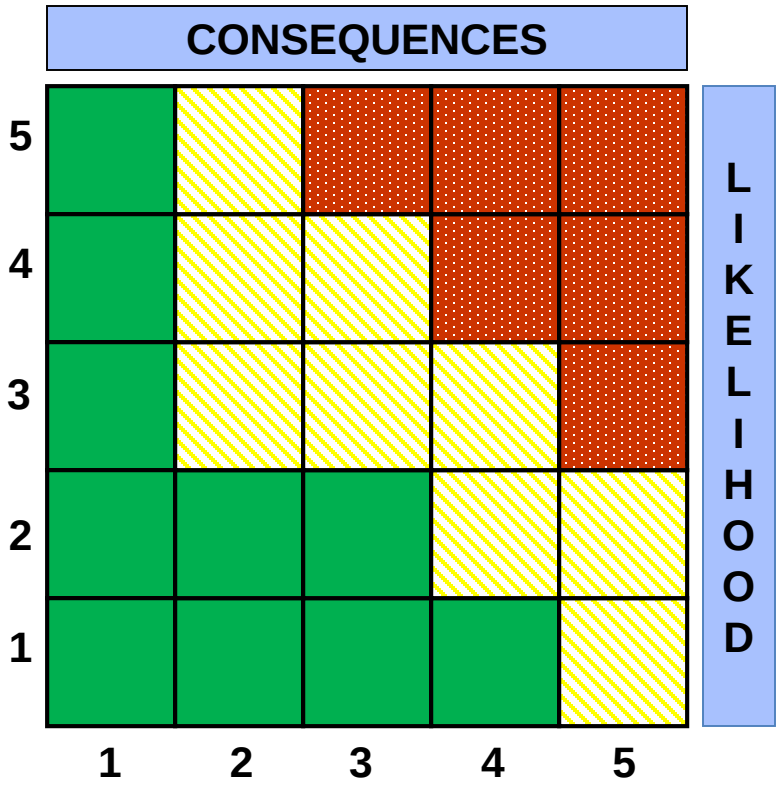
- Be conscious of design trades
  - SWaP trades need to be carefully considered
  - Parts replacement/mitigation schemes
- Test where it solves problems and reduces system risk (risk buy down)
- Categorize and rank the risks relative to one another

Risk Buy Down by Radiation Testing



Categorize and Rank Risks

- Translation of a 5x5 to Relative Risk
  - Consequence x Relative Risk
  - Relative risk is ratio of worst consequence probability to lowest risk probability (0 to 1)
  - Similar to tracking top risks



- 4. Iterate the process

Ongoing Effort

- Design trades drive the risks
  - Know these trades and their effect on radiation concerns
  - Some simple questions can determine major radiation concerns and how to deal with them:
    - Mission Life
    - Orbit
    - Redundancy
    - Device Process, Family, Function
    - Class
  - Internal effort to raise awareness

Questions?